Progress Report

Engaging Agricultural Communities in the Great Plains of the United States with the Applications and Developments of Climate Prediction and Information

(NOAA Project GC02-181)

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I. Preliminary Materials

A. Project Abstract

This proposal details a plan by researchers at the University of Nebraska-Lincoln to conduct a series of workshops and surveys, and develop and analyze a decision-behavioral model to understand: (1) how the effects of climate variability are perceived as represented in climate forecasts and products used by producers in three agroecozones representing different grain production regimes, rainfed, irrigated, and a mix of both in the western Corn Belt/eastern Nebraska area; (2) what are the attributes entering producers' thinking and their interplay to formulate producers' intentions and decision to act on and use or not use climate forecasts; and (3) how we can improve climate education and accordingly modify climate forecasts and products so to increase the effect of climate forecasts in farmer's thinking and decision-making. The goals are to raise the value of climate forecasts and products and, thus, climate research in the agricultural communities in the Great Plains, with the goal of reducing their vulnerability to climate risks in a changing environment.

The specific objectives of the project are to: (1) identify those agricultural activities most sensitive to climate variability in the study area and determine how the application of climate forecasts and products (or improved products) would help producers optimize production and profit; (2) develop evaluation devices and methods to gather information and understand those factors that agricultural producers consider when making decisions with climate products, relative to their farm landscape and inherent climate variability and those social, environmental, and economic constraints that affect the way producers formulate climate forecasts in making their decisions; (3) use materials gathered in (2) and develop a model that will quantify the probability for producers to act, and the extent to which they act, due to climate products influencing their decisions; and (4) develop a continuous monitoring system to update our understanding of the evolution of producers' thinking process over time, particularly, changes in the probability of using climate forecasts/products and their perception of the use of these products in their decisions after major climate events. This system will provide data to update the model developed in (3) and from this analysis to find adjustments for climate predictions and ways to improve predictions. This system can be used as a protocol for expanding this methodology into other counties in Nebraska and other states in the Great Plains region.

These objectives and goals are attainable in the proposed time frame because of existing substantial understanding of the agroecozones in the region and the characteristics of the farmers' communities. We have accumulated experience in successfully conducting surveys and workshops of various scales, and also have developed decision and behavioral models. With the basis of good understanding of the problem, our integration of multidisciplinary knowledge and experience warrant a successful project.

B. Specific Objectives of This Project

1. To identify the two prerequisites discussed previously for representative counties in the three agroecozones (i.e., the agricultural activities in these areas mostly impacted by climate variation/anomaly), and skillful climate forecasts/products that, after proper use or improvement and use, will provide producers with better tools to capitalize on favorable climate conditions or reduce the impacts of adverse climate conditions to optimize production and profit.

2. To develop evaluation devices and methods to gather information and understand those factors that producers consider when making decisions with climate products, relative to their farm landscape and inherent climate variability and those social, environmental, and economic constraints that affect the way producers formulate climate forecasts in making their decisions.

3. To use materials gathered in 2) and develop a model that will quantify the extent to which the producers will act on using various climate products (e.g., 60-day or 90-day forecast) and complete a particular task (e.g., to plant a drought resistant crop like sorghum or to purchase a particular variety or combination of varieties [fast maturing variety vs. high yield variety] of corn for the next growing season).

4. To develop a continuous monitoring system to update our understanding of the evolution of producers' thinking process over time, particularly, changes in the probability of using climate forecasts/products and their perception of the use of these products in their decisions after major climate events. This system will provide data to update the model developed in (3) and from this analysis to find adjustments for climate predictions/ products and ways to improve them. This information will help engage producers in using these predictions. This system can be used as a protocol for expanding this methodology into other counties in Nebraska and other states in the Great Plains region.

C. Approach

There are two steps in taking an action with regard to using climate forecasts/information in agricultural decisions. First, farmers form an intention to use a forecast and, second, carry out the intention. We will refer to this two-step process as the decision-making process. It involves weighing many factors. They can be categorized into four groups: 1) the pursuit of self-interest, 2) the pursuit of other-interest, a kind of community or common interest, 3) political and physical environmental constraints and outside influences, and the personal ability to do, and 4) the biophysical situation represented in a particular agroecozone. By weighing these factors, an intention is formed in a person's mind to take an action. Whether this intention is executed as an economic action depends on further evaluation of personal ability and capability.

Climate forecasts are one of the factors and it has three attributes in this decision-making: 1) it provides a possible future physical environment the farmer's operation will be in, 2) a farmer can benefit from forecasts but needs adequate knowledge and skill to understand and use them, and 3) forecasts have intrinsic uncertainties and, therefore, consequences the farmer should consider. Also, there is a community dimension in using forecasts, in that others in the communities laying claim on a producer's actions may not see forecasts as useful tools. It remains unknown as to how the self and community (others) interest interacts, and how outside influences affect producers' thinking and decision-making, and, in conjunction with abilities, affect actual action. We will provide insights on this question and quantitative tools to measure how farmers in the study areas develop their intention to use or not use climate forecasts in making their farming decision and what factors raise the probability for them to take actions of using this information. We will develop and analyze a decision-behavioral model building on previous work by principal investigators of this project and others. Mathematically, if we posit $I_S(A; L)$ reflecting a farmer's self-interest in applying a climate forecast, L, with ability, A (e.g., his/her knowledge and skill of using climate forecasts), $I_C(A; L)$ the farmer's community-interest in using the same forecast in a decision, $I_A(L; A)$ the interest in the outside influence and ability factor associated with using the specific forecast L, and influence of the biophysical situation on a farmer's intension to use L, $I_Z(L; Z)$, our theories interpret that the possibility for the farmer to decide *and* use L may be determined by:

$$\Phi = B_S I_S(A;L) + B_C I_C(A;L) + B_A I_A(L;A) + B_Z I_Z(L;Z) + B_D[I_S \times I_C] + B_1[I_A \times I_S] + B_2[I_A \times I_C] + B_3[I_Z \times I_A] + B_4[I_Z \times I_B] + B_5[I_Z \times I_C] + \varepsilon. \quad (1)$$

In (1), Φ is the probability of taking an action, and the coefficients, *B*, weigh the effect of each factor and their interaction on intent and actual action. To develop this model, we will use survey methods to gather information and determine the coefficients in (1) using a least-square regression method along with variance analysis.

The survey questions will be designed based on the theoretical framework of Ajzen and Fishbein to obtain adequate information on attributes entering agricultural producers' decision-making and for determining the coefficients in (1). These questions will be brought to focus group meetings and workshops in study counties and revised and amended for both easy understanding for producers and accuracy in describing the relevant decision processes. After finalizing the survey, we will conduct a mail survey in study counties in different agroecozones. Answers to survey questions will be analyzed to develop the model (1). After the model is developed, it will be analyzed to understand what role climate forecast has played in farming decisions, and what may be changed, e.g., improving agricultural producers' ability of interpreting forecasts and/or imposing policies favoring producers' use of climate forecasts, in order to raise the frequency of using forecasts and using them correctly in decisions.

Because thinking is a dynamic process, producers' intention of using or not using climate forecasts and their perception of climate effect changes with time as personal knowledge, information technology, and forecast skills improve. It is important to know how each of these attributes influences a producer's decision-making so that future effective programs can be developed to improve use of climate forecasts and information. For this reason, we will develop an Internet survey tool, which will be used repeatedly on annual basis to monitor and understand decision-making related to use of climate forecasts.

D. A Description of Matching Funds Used for This Project

Collaborative Interdisciplinary Projects

Spurred by this NOAA project, members of this research team continue to receive multiple awards from other NOAA climate research programs and from USDA Risk Management Agency to further understand decision making process of farmers and their communities and to transition climate information into decision support. For example, the research of this NOAA project has indirectly supported efforts in building drought management decision support systems that farmers, University Extensions, agribusiness, and USDA agencies can use to evaluate current information and historical drought events and access to strategies and recommendations for decision-making. Collectively, these efforts have resulted in over $7.2 million in competitive grants.

Other Matching Funds

Several project members have devoted more than double of their time originally budgeted for the project. The salary and fringes from the extra time put on the project may be considered as matching funds. In addition, our secretaries have provided a great deal of support to this project for no pay from it. Their time and associated salary and fringe also are matching funds of this project.

II. Interactions

A. Interactions with Decision Makers (who were either impacted or consulted as part of this study)

In this project period was devoted to further understanding the survey data and developing the decision-making models. No focus group was organized.

B. Interactions with the Climate Forecasting Community

Continued effort was put in contacting the NOAA CPC forecasters. A plan was developed to visit units of CPC and NOAA headquarter to share findings of this research, from both surveys and modeling work, and concerns of weather and climate predictions and was tried to carry out. However, because of schedule conflicts with several key personnel in those units the plan did not go through. We were suggested to contact those units and schedule the visit in a later time.

C. Coordination with other projects of the NOAA Climate and Societal Interaction Division

Interactions with several projects of the NOAA Climate and Societal Interaction Division were initiated during the Third Climate Prediction Application Science Workshop at Columbia University, Palisades, NY, in March 2005. Communications helped achieve exchange of idea and research approach in understanding human aspects of climate change. The interaction has been continued since the workshop.

III. Accomplishments

A. Research Tasks Accomplished

Two major tasks were accomplished in this 12-month period and they are detailed in the following.

a) Modeling study

The main focus of this project is to examine the Theory of Planned Behavior (TPB) of Ajzen (1991) in the context of farmer's decision making related to use of weather forecasts and information, and to use the theory to understand the reasons why farmers do or do not use forecast information in their decision making. This understanding is important for us to improve forecasts and to develop relevant education methods to improve correct use of forecast information in decision making. Substantive progress has been made in this 12-month period.

In the TPB construct, attitude, social norms, and perceived behavioral control are found to explain the influence of forecasts on farming decisions. Attitude toward use of forecasts had the most profound positive influence on the outcome of all the decisions, followed by norms. Norms played an important role mainly in the agronomic decisions. In addition, interactive effects of controllability, self-efficacy, and general preference for control provide insight into the role of control in farmers' decisions. The revised TPB model with inclusion of an economic control term (TPD) predicted the capital constraint to be the main driving force in the farm decisions. In the TPD construct, the farm sales variable as a measure of financial ability intensified and clarified the role of perceived control on farmer's behavior, while also enhancing the statistical robustness of the attitude and norms variables. Furthermore, the increase in the orientation toward the other's-interest, as reflected in the balance variable, leading to less influence of forecasts suggests that farmers perceived weather and climate information and forecasts as mainly a profit-oriented decision. Removal of the attitude variable and inclusion of the synergy variable that indicates farmers' choice of inputs at the balance of their interests helped reveal the sensitivity and significance of the rest of the explanatory elements of the TPD model. These results are detailed in the manuscript on the TPB model currently in press (a copy can be found at the project webpage).

b) Identify demographic and environmental influence on decision behaviors

The TPB model reveals a "global relationship" of those factors influencing decisions and farmers intention to use climate forecast and information in decisions. Although this global relationship is robust (at least based on available tests and our results for farming communities), some factors in TBP may play a more or less significant role in decision-making for people living in different environment. This variation reflects interactions of human and natural environment and is the very reason that we have proposed to study the three counties (instead of one) with rather different climate and cropping environments and availability of water resources. To identify variations of the factors attributing to differences in decision behavior of farmers in different climate and resource environment we developed TBP for each county in the study, and compared the models among the counties. Preliminary results of these comparison and contrast

show that farmers in the county with the highest irrigation percentages (available water resources), the greatest percentages of income from farming (economic strength and resources), and the greatest technological capabilities, used forecast products the most. Also they valued climate products and the opinions of others more than farmers in the other two counties. However, the TPB model was less predictive of past farmer behavior for this county than for the other two counties with less available resources, even though the same dependent variables were significant predictors. Percent of acres irrigated and percent of income from farming were found to account for some differences between counties. These results are examined to gain further understanding of environmental and regional climate effects on decision behavior.

In the meantime, the Geographical Information System (GIS) method was used to more accurately describe spatial changes of the influence of attitude, social norm, perceived behavior control and economic capability on decision behavior of farmers across the three-county area. An hourly student was hired in grouping the survey data into GIS format. He has been working with the Co-PI to develop methods to quantify the variations of the TPB variables and decision making changes in the area. This work is still in progress.

B. List of Papers and Publications

Hu, Q., L.M. PytlikZillig, G.D. Lynne, K.G. Hubbard, W.J. Waltman, M.J. Hayes, A.J. Tomkins, and D.A. Wilhite, 2005: Understanding farmers' forecast use from their beliefs, values, social norms, and perceived obstacles. J. Appl. Meteor. Climatol. (in press)

Artikov, I., S.J. Hoffman, G.D. Lynne, L.M. PytlikZillig, Q. Hu, A.J. Tomkins, K.G. Hubbard, M.J. Hayes, and W.J. Waltman, 2005: Understanding the influence of climate forecasts on farmer decisions as planned behavior. J Appl. Meteor. Climatol. (in press)

Artikov, I., 2005: Understanding Farmers' Decision Making Under the Influence of Weather and Climate Information and Forecasts. M.S. Thesis, Department of Agricultural Economics, University of Nebraska-Lincoln. May 2005. 195pp.

List of presentations:

Hu, Q., 2005: Improving farmers' forecast use from understanding their beliefs, social norms, and perceived controls. Third Climate Prediction Application Science Workshop, Columbia University, Palisades, NY, March 2005.

Artikov, I., and G. D. Lynne, 2005: Climate Change and Farm Use of Weather Information. Presented at the American Association of Agricultural Economics annual meeting, Providence, RI, July, 2005.

C. Discussion of Significant Deviations

Our research in this period followed original plan without any significant deviation.

IV. Relevance to the Field of Human-Environment Interactions

A. How the results of your project are furthering the field of understanding and analyzing the use of climate information in decision-making

The current understanding of the use of climate information/forecast by agricultural producers has been based on a few surveys focusing on usefulness of forecasts in making agricultural decisions and on potential of using forecasts to improve production. Little attention has been given to the issues of why producers do or do not use forecasts in specific farming decisions, and how an intention of using climate forecasts forms through human psychological processes involving interactions among personality, personal interest and orientation to community, ability of understanding the forecasts, financial ability, and existing government policy. How economic and social environments affect these interactions in development of the intention and its execution? These fundamental questions are addressed in this study. Answers to these questions will further our understanding of decision-making related to use or not use climate forecasts and lead to identifying effective ways to improve the use of climate information in agricultural decision-making.

The survey tool designed in this project to collect and extract information for quantifying those human dimension variables in decisions to use or not use forecasts in farming practice can be used to collect and extract similar information for other decision behaviors, e.g., water resources management decisions, and understand the decision-making process in the framework of TBP. This also provides a platform for comparisons of decision behavior in making different decisions or making the same decision in different regions in the U.S. and other countries.

B. How this research builds on previously funded HDGEC research via other federal agencies

Please see I-D. Some of the projects founded by other federal agencies started earlier than this NOAA project. As depicted in that section these projects are collaborative and interactive and mutually benefiting one another.

C. How is your project explicitly contributing to the following areas of study?

1. **Adaptations to long-term climate change**

   In order to adapting to climate change, the society or a particular community, such as the agricultural community in the Great Plains, needs to not only know the climate change but also use the climate information in their planning and decision-making. Adaptation is established when climate information is integrated in short- and long-term plans and in decision behavior. Thus, the core issue in the adaptation to climate change is how to integrate the climate information in the decision behavior. This study will reveal the decision behavior of agricultural producers in the Great Plains, disclose how much climate information has been used in their decision-making, and identify ways to improve the use of climate information in decision behavior and hence more effective adaptation.

2. **Natural hazards mitigation**

An effective mitigation of natural hazards is to "plan ahead." To plan ahead, we need to consider expected future hazardous conditions, e.g., droughts, floods, and tornadoes, and the probability for such conditions to occur, build this information in plans, and execute them accordingly. Again, the decision to build the information in a plan is a decision to use climate forecasts. How much do we use climate forecasts and information and how do we use them in planning? These questions need to be addressed in order to improve mitigation of natural hazards. This study will address these questions and, by showing ways to improve use of climate forecasts and information, will lead to better mitigation methods.

3. Institutional dimensions of global change

Findings and methods developed from this project will be useful to the National Drought Mitigation Center and the High Plains Regional Climate Center participating in this project. Through their activities the findings could influence governmental and institutional decisions related to climate change.

4. Economic value of climate forecasts

Although a quantitative measure of economic value of using a particular climate forecast will not be calculated in this project, its results will show the bulk of economic value of forecasts. For example, Figures III-7 and III-8 show the expected value of long-term climate forecasts by agricultural producers in choosing best crops for a growing season and for plans to maximize crop revenue in marketing. These decisions involving using climate forecasts will bring economic values to the producers. By improving the use of climate forecasts this project will enhance economic values of climate forecasts to agricultural producers.

5. Developing tools for decision-makers and end-users

This project will lead to improving forecasts' contents and formats to raise the frequency of using climate forecasts by agricultural decision-makers.

6. Sustainability of vulnerable areas and/or people

The Great Plains is a vulnerable area for agriculture and the area's farming community and economy are particularly sensitive to climate change. Establishing a habit and skill of correctly using climate forecasts and information in planning and decision-making is an important strategy to sustain the community and economic development of the area.

7. Matching new scientific information with local/indigenous knowledge

Nebraska is in a unique geographical location with large east-west gradient of precipitation and large north-south gradient of temperature. In this environment, both regional and local weather and climate information is important for decision-making. In this project, our understanding of agricultural producers' perception of local climate information, e.g., those produced by the High Plain Regional Climate Center, will help the Center improve both its local climate information

and ways to deliver it to promote the use of the local information in decision-making.

8. The role of public policy in the use of climate information

Findings of this project on concerns and obstacles affecting agricultural producers' use of climate forecasts and information will be useful for revising policies such that they can remove the obstacles and encourage use of climate forecasts and information in decision-making.

9. Socioeconomic impacts of decadal climate variability

While helping establish a habit and skill to use long-term (including decadal scale) climate forecasts and information, this project will help to bring the long-term climate change information into strategic planning, thus either enhancing the favorable climate impact on socioeconomic well being of regional societies or reducing adverse impacts of climate change on regional socioeconomics.

10. Other (e.g., gender issues, ways of communicating uncertain information)

A goal of this project is to improve expressing and communicating the uncertainties associated with climate forecasts and information and to help the end-users of the forecasts, e.g., the agricultural producers, to develop skills to correctly use the forecasts in their decision-making.

V. Graphics

A. Graphic depicting the overall project framework/approach

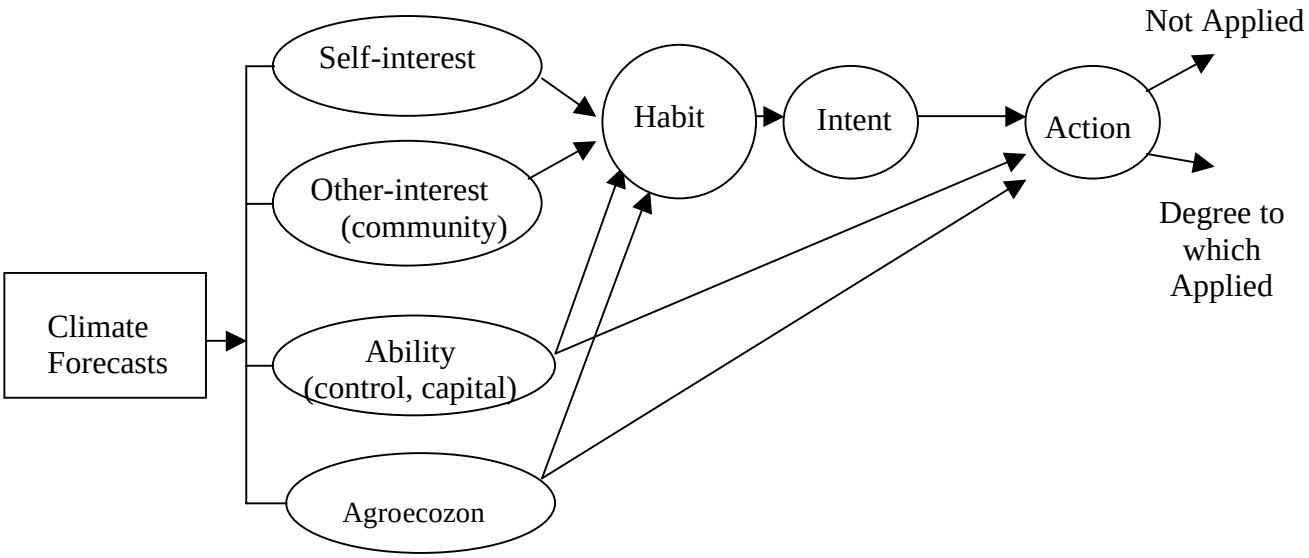

Figure V-1. Intention and action to adopt and apply climate forecast/information in decision-making.

VI. Website address for further information

http://snrs.unl.edu/noaa-hdgc